Coolable layer system

The invention relates to a coolable layer system in accordance with the preamble of claim 1.

US-A 5,080,557 has disclosed a layer system in which a porous structure through which a cooling medium flows is arranged beneath a wall. This layer structure is relatively thick and difficult to cool.

US-A 5,820,337, US-A 5,640,767 and US-A 5,392,515 show turbine blades or vanes which are formed from a substrate and in which cooling passages are arranged below an outer wall which includes the same material as the substrate. The cooling of the outermost coating on the outer wall is in many cases inadequate.

EP 1 007 271 B1 shows an impingement-cooled gas turbine blade or vane which, however, does not have any cooling passages below the outer wall. The elevations serve to support the outer wall and do not form cooling passages.

Therefore, it is an object of the invention to improve the cooling of a layer system.

The object is achieved by a coolable layer system as claimed in claim 1.

The subclaims list further advantageous measures for improving the cooled layer system.

The measures listed in the subclaims can be combined with one another in advantageous ways.

Exemplary embodiments of the invention are explained below. In the drawings:

FIG. 1 shows a first exemplary embodiment of the coolable layer system,

FIG. 2 shows a further exemplary embodiment of a coolable layer system, and

FIGS. 3, 4, 6 show further modifications of the coolable layer system, and

FIG. 5 shows a specially designed cooling passage.

Figure 1 shows a coolable layer system 1.
The layer system 1 has a substrate 4. The substrate 4 is, for example, a ceramic or a metal, in particular a superalloy (nickel-base or cobalt-base) for gas turbine components (turbine blades or vanes, combustion chamber linings, etc.).
At least one coating 7 has been applied to the substrate 4.
The coating 7 may be a metallic MCrAlY coating as used for gas turbine blades or vanes (M = Cr or Fe or Ni; Y = yttrium or rare earth).
Moreover, it is also possible for a ceramic coating, for example a thermal barrier coating 9 (FIG. 6), to be applied to the coating 7.

Starting from the surface 22 of the substrate 4, in this case at least one cooling passage 10 is formed, for example within the coating 7, i.e. the cooling passage 10 is formed by removal of material from the coating 7 or by application of the coating 7 in such a way that it leaves clear a corresponding cavity.
Therefore, the majority of the peripheral surface of the cooling passage 10 is formed by the coating 7. The surface 22 remains substantially unchanged.

Cooling medium is supplied via a coolant feed 13 which is formed at least in the substrate 4 and leads into at least one cooling passage 10.
The cooling passages 10 are therefore arranged in the immediate vicinity of an outer surface, which can come into contact with a hot gas 8. This allows better cooling of the coating 7, which is exposed to higher temperatures than the substrate 4.

Figure 2 shows a further exemplary embodiment of a coolable layer system 1.
In this case, the cooling passages 10 are formed not by passages within the coating 7 but rather, for example, by recesses 23 arranged in the substrate 4.
The coating 7 forms part of the inner surface of the cooling passage 10 and closes it off on the outer side.

It is equally possible for the cooling passages 10 to be arranged both in the substrate 4 and in the coating 7.

Figure 6 shows cooling passages 10 between two coatings 7, 9.
The cooling passage 10 may also be formed by a recess 23 (indicated by dashed lines) in the coating 7.

The cooling passages 10 shown in Figures 1, 6 are produced, for example, in the following way.
Webs comprising a filler material which in cross section correspond to the cooling passages 10 to be produced are laid on the surface 22 of the substrate 4 or on the surface of the coating 7.
The substrate 4 or the coating 7 is then coated with the coating 7 or the coating 9, respectively (plasma

spraying, physical vapor deposition (PVD), chemical vapor deposition (CVD), etc.).
Then, the webs comprising the filing material are removed. The material for the webs consists, for example, of graphite, which can be pyrolyzed or leached out after the coating with the coating 7, 9.
Other materials are also possible for the filling material.

To produce the cooling passages 10 shown in Figure 2, corresponding recesses 23 are introduced into the surface 22 of the substrate. The recesses 23 are filled, for example, with a filling material which prevents material of the coating 7 from penetrating into the cooling passages 10 during the coating of the substrate 4.
After the coating 7 has been applied or an outer wall has been applied, the filling material is removed again, so that the cooling passages 10 are formed.

Figure 3 shows the arrangement of cooling passages 10 in accordance with Figures 1, 2 and 6 on a surface of a component 1 (layer system).
The layer system 1 is, for example, a turbine blade or vane which extends along a radial direction 16. At least one cooling passage 10 extends in an axial direction 19, perpendicular (at 90°) to the radial direction 16.

The cooling passages 10 may also run at an angle other than 90° to the radial axis 16 (FIG. 4), for example approximately parallel to the radial direction 16 (0°).
It is also possible for all the cooling passages 10 to extend in one direction. Groups of cooling passages may also run parallel to one another.

Figure 4 shows a further possible arrangement of cooling passages 10 in accordance with Figures 1, 2 and 6 on a surface 22 or a coating 7 of a component 1.

At least two cooling passages 10 cross one another and are in communication with one another, i.e. a cooling medium can flow out of the cooling passage 10 into another cooling passage 10. Consequently, there is no need for complex, meandering cooling passages, since the crossed pattern of the cooling passages 10 covers at least part and in particular all of the surface of the component 1 which is to be cooled, i.e. the crossed pattern and the crossings of the cooling passages extend at least partially or completely over or beneath the surface that is to be cooled.

In Figure 4, by way of example, there are eight crossings of cooling passages 10.

The surface to be cooled may be a subregion or all of the surface of a main blade or vane part of a turbine blade or vane (component 1).

If a cooling passage 10 has become blocked at one location, the cooling medium can nevertheless continue to flow via the other cooling passages.

The cooling medium K flows via an inlet for example into the cooling passages 10′ and 10″. From the cooling passage 10″, the cooling medium passes directly into the cooling passage 10‴ and 10⁗, etc.

The cooling passages 10 are in this case arranged, for example, in groups that are crosswise with respect to one another, with the cooling passages 10 within a group running parallel to one another.

Other arrangements of cooling passages 10 which cross one another are conceivable.

It is also possible for cooling passages 10 which cross one another and meandering cooling passages 10 to cover a surface that is to be cooled by virtue of meandering cooling passages being connected to cooling passages which cross one another.

Figure 5 shows a specially designed cooling passage 10, for example based on FIG. 1.
Since the cooling passage 10 at least partially adjoins the coating 7 (not shown) or an outer wall, the cooling passage 10 of the layer system 1 that is to be produced, without coatings or an outer wall, has an opening 24 at the surface 22.
The angle α between the surface 22 and the inner surface of the cooling passage 10 at the opening 24 is not 90°. This means that the cooling passage 10 has undercuts 26 with respect to the surface 22.
As a result, in the event of a high thermal gradient between outer, hot coating 7, 9 or the wall and cooling passage 10, thermal stresses between the coatings 7, 9 or the wall and the substrate 4 are reduced.
A cooling passage 10 with undercuts 26 of this type may also be arranged in the coating 7 (FIG. 6).

A cooling passage 10 with undercuts 26 in the substrate 4 is produced, for example, using a milling cutter or grinding head 25 which is of spherical, hemispherical or conical form at one end.
First of all, the milling cutter 25 or some other form of cylindrical drill produces a hole in the substrate 4 by virtue of being moved in a drilling direction 29 which is virtually perpendicular to the surface 22 of the substrate 4. Then, the milling cutter 25 is moved to and fro in a direction 32 perpendicular to the drilling direction 29, as indicated by the arrow, thereby producing the undercuts 26 in the substrate 4.
The various positions of the milling cutter 25 during the movement to and fro are indicated by dashed lines.